

(12) UK Patent Application (19) GB (11) 2 084 266 A

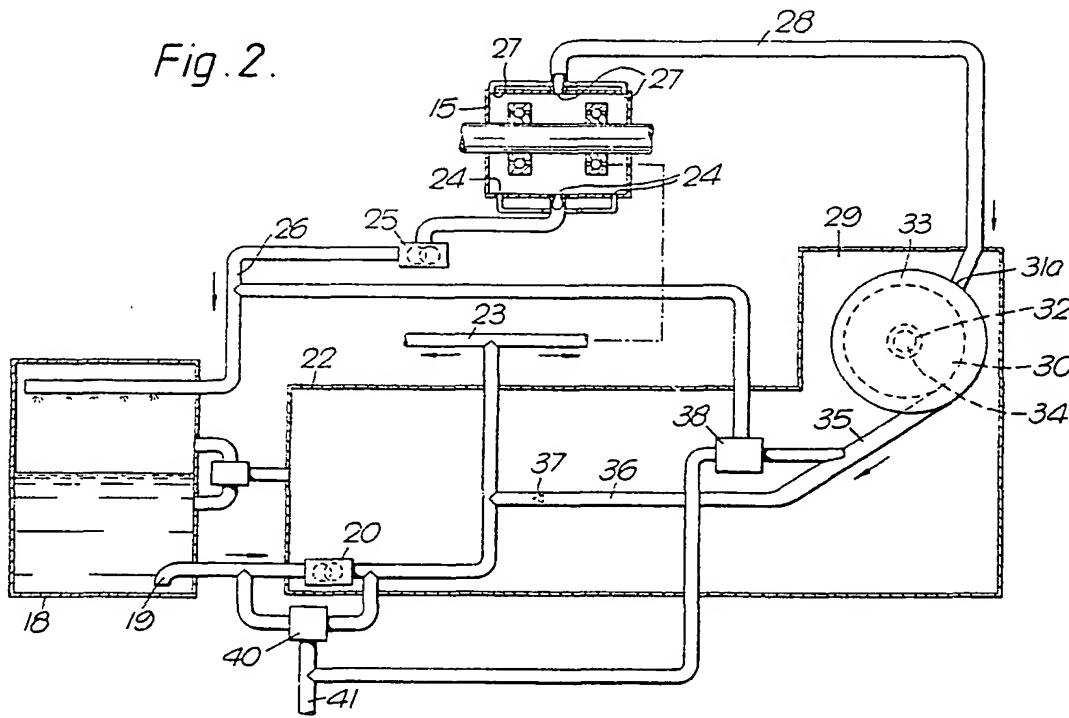
(21) Application No 8129094
(22) Date of filing 25 Sep 1981
(30) Priority data
(31) 8031265
(32) 26 Sep 1980
(33) United Kingdom (GB)
(43) Application published
7 Apr 1982
(51) INT CL³
F16N 29/02
(52) Domestic classification
F2A 33 35A1
F1G 14 3
(56) Documents cited
GB 1597404
(58) Field of search
F2A
(71) Applicants
Rolls-Royce Limited,
65 Buckingham Gate,
London SW1E 6AT
(72) Inventor
Stanley Smith
(74) Agent
J. Waite,
Rolls-Royce Limited,
Patents Department, P.O.
Box 31, Derby DE2 8BJ

(54) Oil system for aircraft gas turbine engine

(57) A fully aerobic oil system for an aircraft gas turbine engine includes two re-circulatory oil systems the pumps for which have inlets 19 and 31a disposed at locations in the engine such that when one inlet is starved of oil, due to the aircraft attitude changing, oil will be supplied to the other one. A breather (30) of the type described in UK Patent No. 1,508,212 is positioned in the gearbox 22 and provides the lowest pressure point in the system. The bearing chambers are pressurised with air from the engine and the air/oil mixture in each chamber is vented via vents 27 to the

breather where the air and oil are separated. The breather is used to pump the separated oil back to the oil tank 18 via line 35 and relief valve 38. In normal flight pump 20 supplies the bearing chambers via gallery 23 from the tank 18, relief valve 38 being open and check valve 37 being closed, and oil is returned via line 26. When the inlet 19 is starved of oil because of inverted flight, the pressure in gallery 23 drops to the extent that check valve 37 opens and the breather 30 then pumps oil from the gearbox via pipe 36 and gallery 23 to the bearings, which oil is returned to the breather via pipe 28. In an alternative embodiment, pump 20 is common to both re-circulatory oil systems.

Fig. 2.



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Fig. 1.

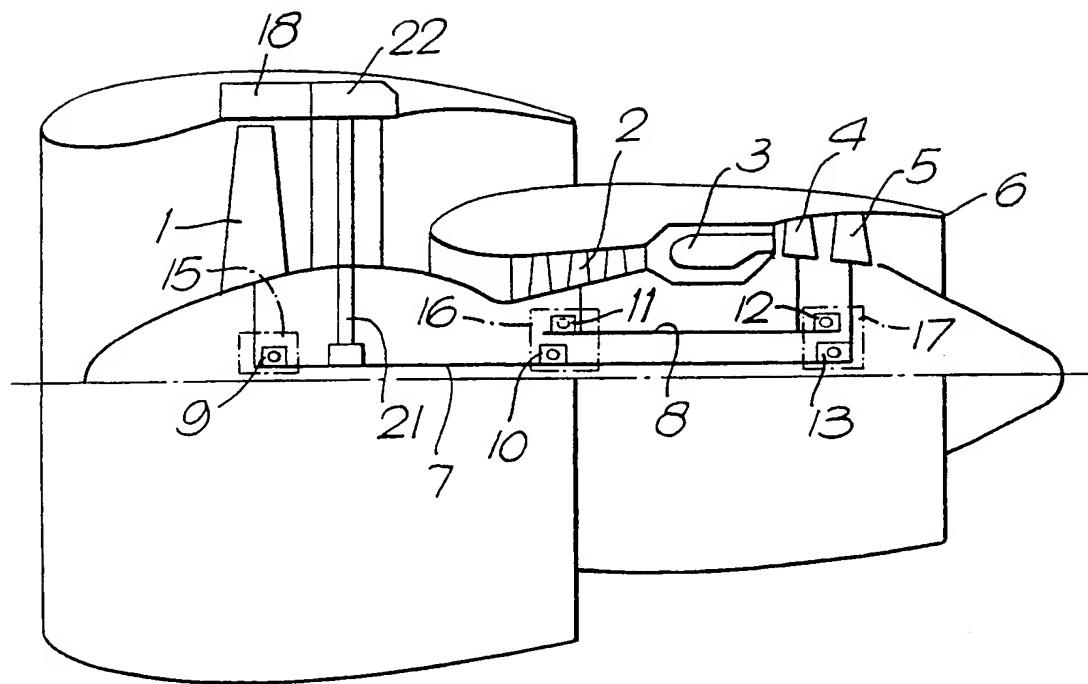
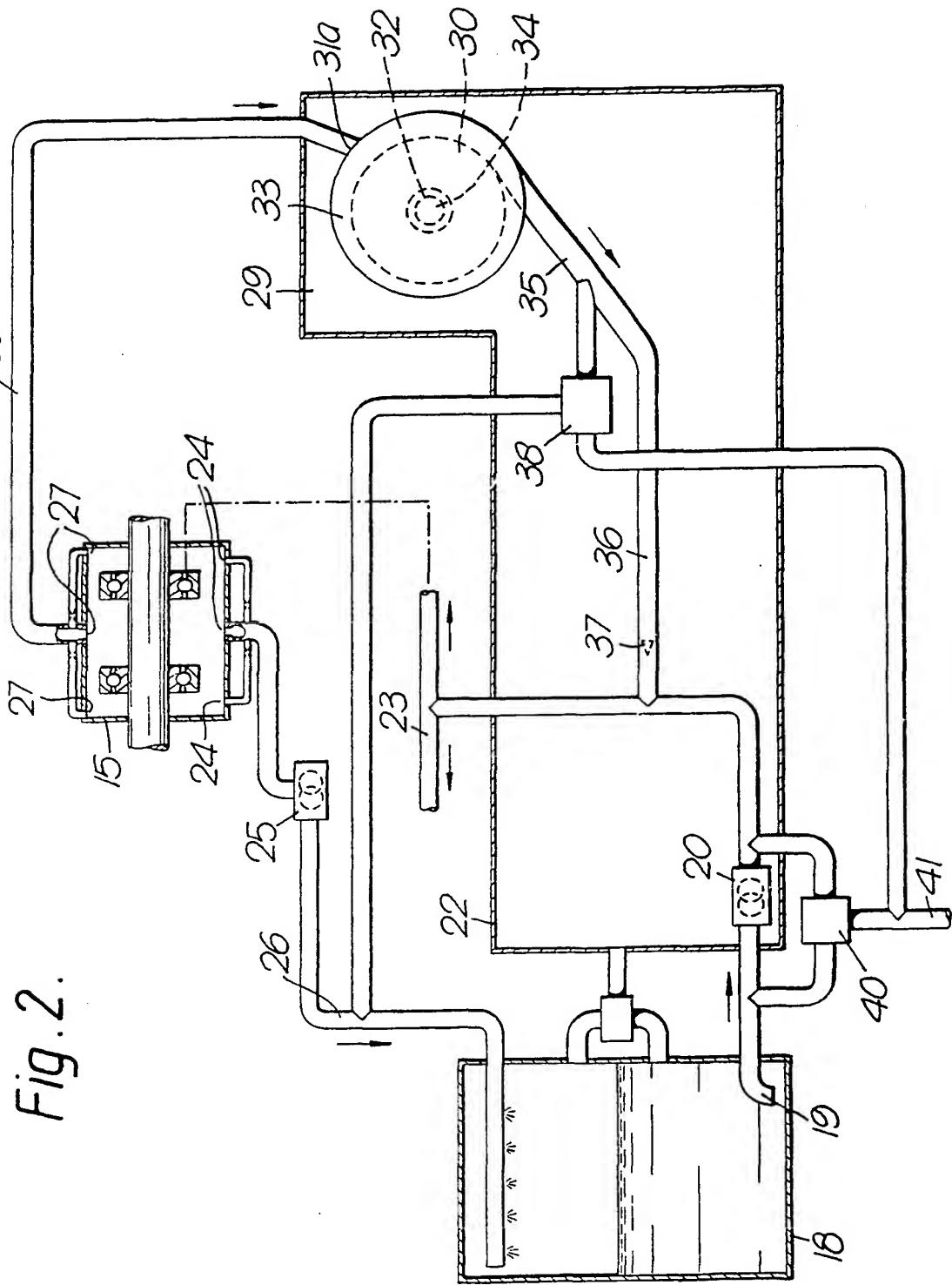


Fig. 2.

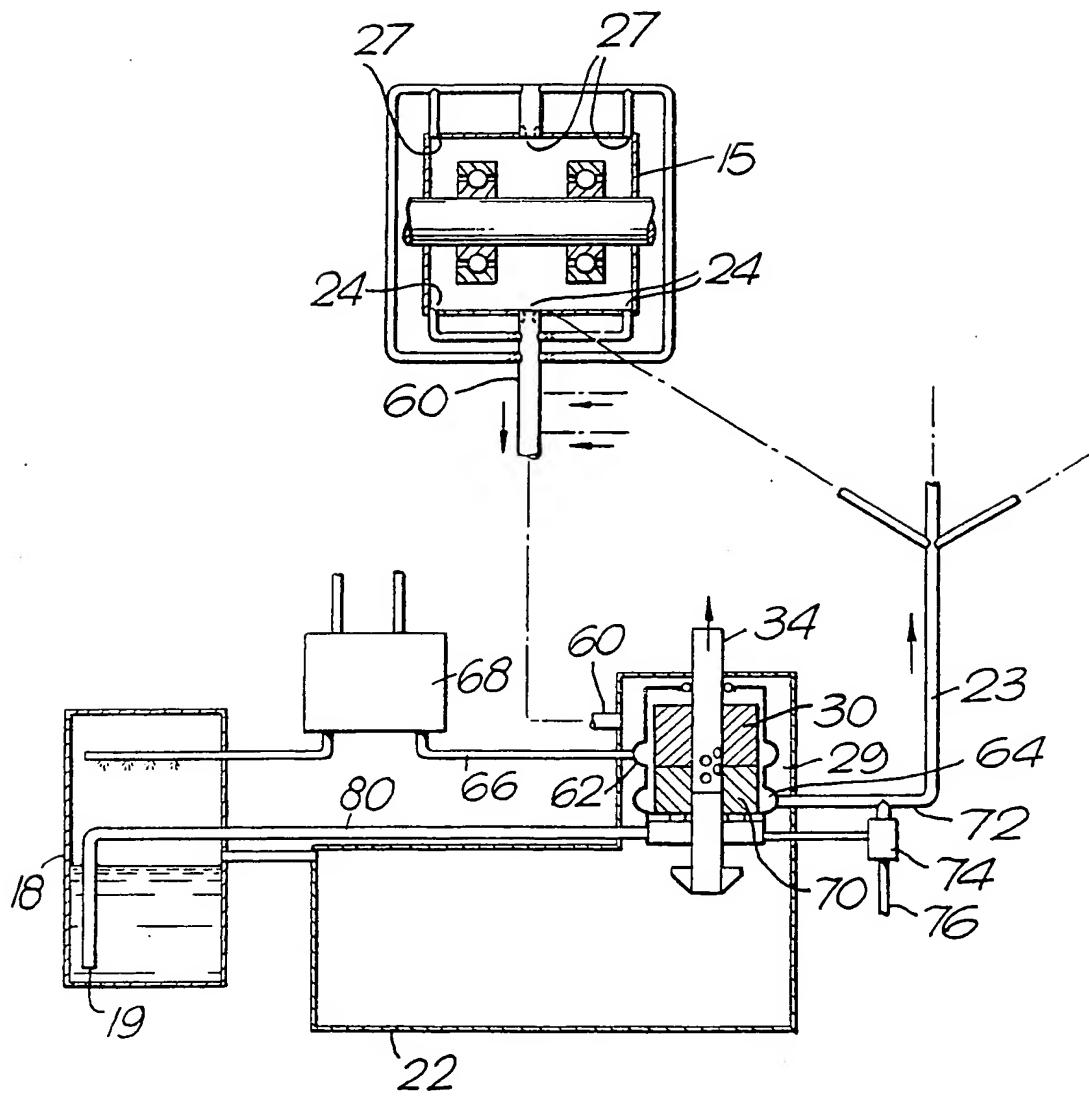
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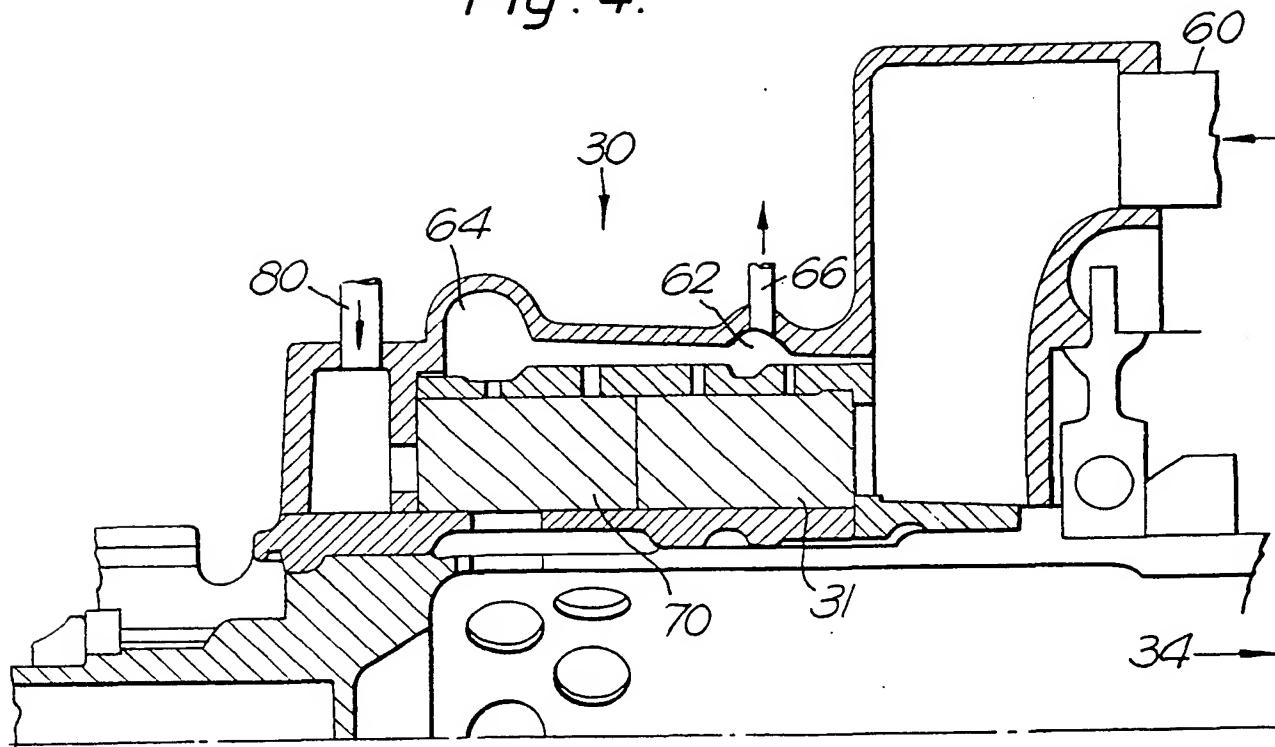
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Fig. 3.



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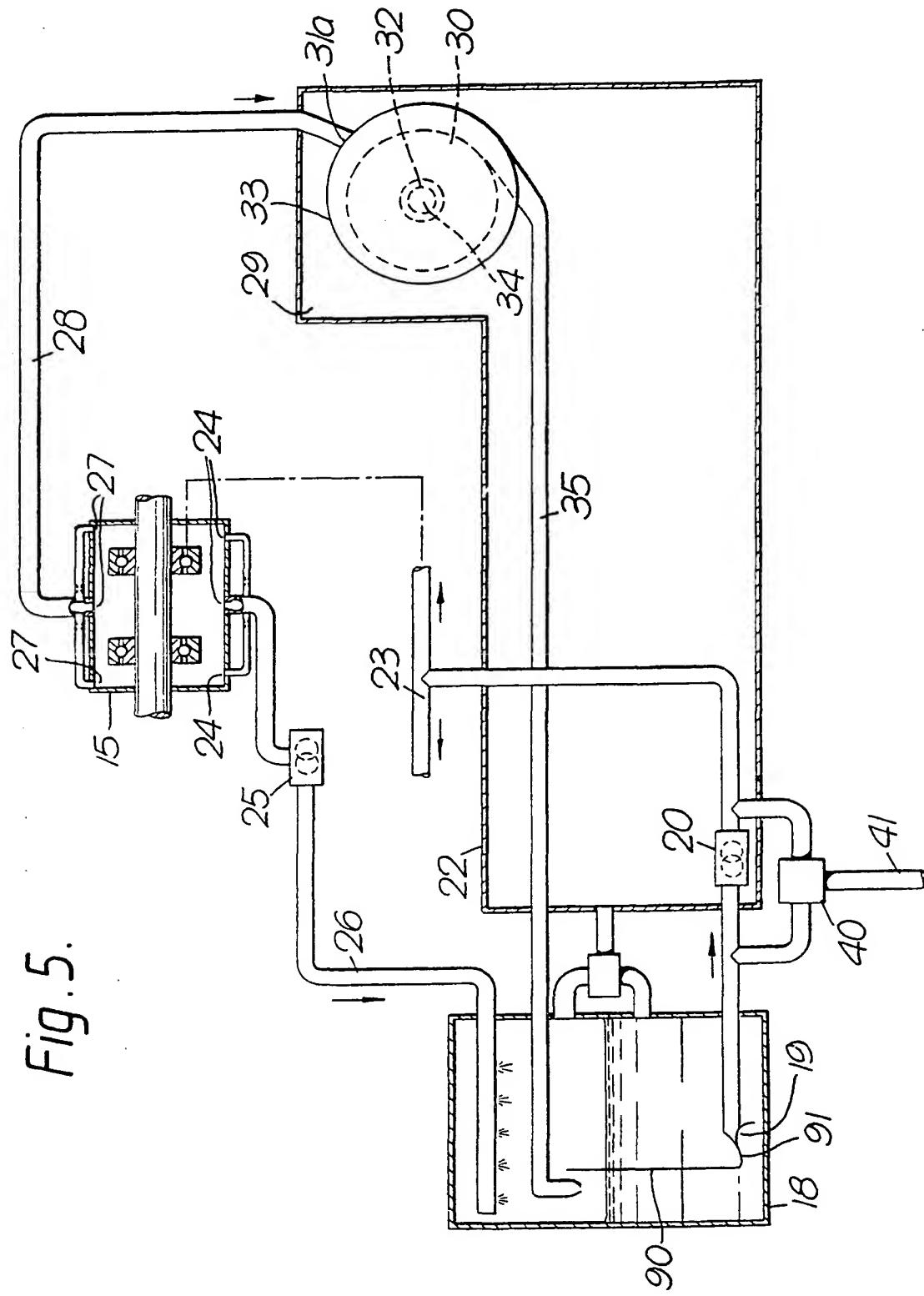
Fig. 4.



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Fig. 5.



SPECIFICATION**Oil system for aircraft gas turbine engine****Description**

- The present invention relates to an oil system for an aircraft gas turbine engine, and relates in particular to an oil system which provides an uninterrupted supply of oil to the engine bearing chambers during any aerobatic manoeuvres of the aircraft.
- Many proposals have been made to avoid the problems associated with oil starvation in the bearing chambers when, for example, an aircraft takes up an inverted attitude, and the oil in the oil tank falls away from the pump inlet preventing the pump from supplying any oil. As a result, in addition to the possibility of bearing failure, the cooling effect of the oil is removed so that the walls of the chamber heat up, increasing the risk of an oil fire when normal oil flow is restored.
- The proposals have usually centred around the provision within the tank of baffles to maintain a reservoir of oil at the pump inlet during inverted flight, and the positioning of the pump inlet within the reservoir so that the pump continues to supply oil for a limited period.
- These solutions have enabled limited aerobatic manoeuvres to be performed but have not enabled aircraft to remain in attitudes other than normal level flight, or to sustain zero or high "g" manoeuvres for significant lengths of time.
- The present invention provides a solution to the problem by ensuring that under those flight conditions during which the main pump inlet in the engine oil tank is deprived of oil due to gravitational or centrifugal effects, oil which is within other areas of the engine falls, or is forced, to another location within the engine from which it is pumped into the main oil supply conduits and thence to the bearings.
- According to the present invention an oil system for an aircraft gas turbine engine comprises a first re-circulatory oil supply system for supplying oil to the engine bearings under some flight conditions of the aircraft, and including a pump having an inlet for receiving oil from a first location in the engine and means for returning the oil to said first location of the engine from the bearings under said flight conditions of the aircraft, and a second re-circulatory oil supply system for supplying oil to the engine bearings at least under certain other flight conditions of the aircraft, said second system including a pump having an inlet disposed in another location of the engine to which engine oil migrates during said other flight conditions of the aircraft and means for returning the oil to said other location from the bearings during said other flight conditions of the aircraft.
- The oil may migrate to the second location under gravity, as for example when the aircraft goes into inverted flight, or may be impelled there by air pressure within the system. In the latter case the second location is preferably the lowest pressure region of the oil system, for example the

65 breather chamber.

The first location will preferably be the usual engine oil tank and the pump of the first oil supply system will be the main engine oil pump which conventionally is a gear pump.

- 70 The second location may be in any area of the engine. In a gravity fed system for example, the second location is preferably opposite to the inlet of the pump of the first system both axially and circumferentially so that the oil in the engine automatically migrates there when the aircraft manoeuvre is such as to take the oil away from the first inlet in the tank. However, in a pressurised system there is more flexibility on the positioning of the second pump inlet.
- 75 In a preferred embodiment the second location is in the breather chamber of the engine gearbox and the breather is of the kind described in our U.K. Patent No. 1,508,212 in which oil separation from the air is carried out in a rotating chamber filled with a rigid porous material sold under the Trade Mark RETIMET by Dunlop Limited. In such an embodiment the breather can operate as a pump and becomes the pump of the second re-circulatory system, and in a further modification of 80 this embodiment the breather may act also as the pump in the first re-circulatory oil system.
- The invention will now be more particularly described by way of example only, and with reference to the accompanying drawings in which:
- 85 90 Figure 1 is a view of a gas turbine engine incorporating an oil system of the present invention,
- Figure 2 is a diagrammatic illustration of the oil system of the engine of Figure 1,
- 95 Figure 3 is a diagrammatic representation of an alternative embodiment of the invention,
- 100 Figure 4 is an enlarged view of a part of the oil system of Figure 3, and,
- 105 Figure 5 is a diagrammatic illustration of a modified system based on that shown in Figure 2.
- Referring now to the drawings, in Figure 1 there is shown a gas turbine engine, which may be of any type, but which in this example includes compressor means 1, 2, combustion equipment 3 and turbine 4, 5. Exhaust gases from the turbine 5 pass to atmosphere through a propulsion nozzle 6. Shafts 7 and 8 interconnect the turbines 4, and 5 with respective compressors 2, 1 and the shafts are supported in bearings 9, 10, 11, 12 and 13, 110 which are located in bearing chambers 15, 16 and 17.
- The bearings are lubricated with oil which is supplied from a tank 18 via a main pump (not shown) which is driven from one of the engine 115 main shafts by a drive shaft 21. A gearbox 22 is situated adjacent the oil tank and contains the gearing required for all the accessory drives. Also the bearing chambers are pressurised by air flowing into them through labyrinth seals in order 120 to prevent oil leakage. As in many conventional oil systems the bearing chambers are vented through a scavenge system whereby the oil is returned to the tank 18. The scavenge system includes the usual oil cooler and breather (not shown in Fig. 1).

It is the manner in which the bearing chambers are scavenged and supplied with oil which is the subject of this invention.

Turning now to Fig. 2 the general layout of one embodiment of the system is shown diagrammatically.

A main pump 20 supplies oil from the tank 18 via an inlet 19 to the main oil supply gallery 23 which directs the oil to the bearing chambers 15,

10 16 and 17 only one of which, 15, is shown. A first series of vents 24 is provided for scavenging the oil from the bearing chambers during steady flight conditions of the aircraft, including some climb or dive conditions. The scavenging may be achieved 15 wholly by the pressurisation of the bearing chamber, or by a combination of the air pressure in the bearing chamber and a conventional scavenging pump 25. The oil is returned to the tank 18 via a first scavenging line 26.

20 Additional vents 27 are provided which communicate via a second scavenging line 28 between the bearing chambers and the gearbox 22. In the gearbox is provided a chamber 29 in which is located the breather 30 which vents the 25 gearbox to atmosphere thus providing the lowest pressure point in the oil system.

The breather, a modified form of which is shown in Fig. 4, consists of at least one compartment 31 filled with a reticulated porous 30 structure sold under the Trade Mark RETIMET by Dunlop Limited and which is mounted on a shaft 32 so as to be rotatable within a housing 33. Emulsified oil from the bearing chambers 15, 16, 17 enters an inlet 31a to the compartment 31 35 where centrifugal force separates the oil from the air. The oil passes to the radially outer part of the compartment for collection and the air passes to the radially inner part and is vented from the system at 34. An example of such a breather is 40 described in our U.K. Patent No. 1,508,212.

Under normal non-aerobatic flight conditions of the aircraft, the main pump 20 operates normally and the scavenging pump 25 and line 26 provide a first re-circulating oil system. During this time the 45 vents 27 vent air from the bearing chambers to the breather chamber 29 in the gearbox, where any oil in the air from the vents or in the gearbox generally is separated out and the air is dumped overboard. It has been found that the centrifugal 50 force on the oil within the rotating porous structure in compartment 31 provides such a high dynamic head that the breather 30 can be used to pump the separated oil back to the tank. Thus a scavenging line 35 is provided from the 55 breather/pump to communicate with the scavenging line 26.

In order to provide for a fully aerobatic oil system, in this embodiment use is made of the pumping capability of the breather to act as a 60 second pump for supplying oil to the bearing chambers.

A bleed line 36 is provided which takes a proportion of the oil from the scavenging line 35 and supplies it to the upstream side of a non-return 65 check valve 37, the downstream side of which

open to the main oil supply gallery 23. A pressure relief valve 38 is also provided in the scavenging line 35 upstream of the bleed line 36 and which is set to open at a pressure slightly lower than that of a

70 relief valve 40 controlling the main pump.

Thus although a continuous supply of oil from the breather/pump is available in the line 36, the pressure relief valve 38 ensures that the pressure in the line 36 is less than that in the main oil 75 supply gallery 23, so that the non-return check valve 37 remains closed and the oil in line 36 spills back to the main scavenging line 26 through line 35 and relief valve 38.

Whenever the aircraft adopts an attitude such 80 that the oil in the tank falls away from the inlet 19 of the main pump, the oil in the gearbox will fall onto the breather, and the oil in the bearing chambers will fall away from the normal scavenging vents 24 and enter one or more of the additional 85 vents 27. Thus the breather will be supplied with a significant amount of oil which will be pumped to the scavenging line 35 and to the bleed line 36. At the same time the pressure in the main oil gallery 23 will fall and the check valve 37 will open to 90 supply the bearing chambers with oil. This supply will be maintained as long as the aircraft remains in the new attitude since the additional vents will continue to return the bearing chamber oil to breather chamber 29 in the gearbox.

95 In addition there will be circulation back towards the main pump 20 but the relief valve 40 will ensure that the pressure in the gallery is maintained. If the normal gallery supply pressure is exceeded by the secondary breather/pump the 100 relief valve will open and allow oil to spill to the inlet of the main pump 20 to prime it and excess oil will return to the tank from which it will spill to the gearbox. Both of the relief valves receive their reference pressure from the bearing chambers via 105 a pressure line 41.

Hence an entire secondary circulation system is established which maintains the oil supply to the bearing chambers until normal flight conditions are restored. By positioning the breather in the 110 gearbox, the only additional features required to give a completely aerobatic oil system are the line 36, and valves 37, 38 so that a very simple and cheap modification is all that is required for a fully aerobatic oil system.

115 Clearly variations may be introduced into the system as described above while still maintaining the principle advantages of the invention. For example, the breather/pump 30 may have a bifurcated outlet communicating respectively with 120 scavenging line 35 and bleed line 36 with consequent re-location of the relief valve to maintain control over the bleed supply.

In the above-described embodiment the breather has been designed such that it can also 125 perform a pumping function. In an alternative arrangement however, an entirely separate secondary system may be provided in which an additional tank or chamber is located at a suitable position on the engine to which is led oil from the 130 additional bearing chamber vents during certain

aerobatic flying conditions. The secondary pump can then be provided at any suitable location provided that the inlet of the pump is positioned in the secondary chamber or tank. The secondary pump may be continuously running or selectively operable by the pilot. If it is continuously running so that the system is fully automatic, provision may have to be made to prevent it burning out or boiling any oil which is provided to keep it primed

10 when not required.

In an alternative embodiment shown in Figures 3 and 4, use is made of the pumping capability of the breather to provide both the main and secondary pumping functions. Also, by relying on

15 the air pressurisation of the bearing chambers the scavenge pumps 25 may be eliminated.

Referring now to Figs. 3 and 4, features common with the embodiment of Figs. 1 and 2 are given the same reference numerals. In this

20 embodiment all of the vents 24 and 27 from the bearing chamber 15 communicate with a single scavenge line 60. It will be understood that the vents from the other two bearing chambers 16 and 17, which are not illustrated, will also

25 communicate with the scavenge line 60.

The hot oil and air mixture from the bearing chambers is impelled due to the air pressure in the bearing chambers along the scavenge line 60 to the inlet of the breather 30.

30 In this particular embodiment the breather housing is provided with two oil collecting scrolls 62 and 64 into which oil, which has been separated from the air/oil mixture entering the breather, is impelled at high rotational speed. The

35 dynamic head of the oil is used to deliver the oil from the scrolls to a location of use without the need for any additional pumps.

Oil in scroll 62 passes into a pipe 66 which returns it via a cooler 68 to the tank 18 from

40 which is forced by the pressure in the oil tank to the inlet 19 of the main pump 20. A line 80 conveys oil from inlet 19 to an additional rotating compartment 70 filled with RETIMET on the breather shaft, which constitutes the main pump

45 20. In passing through compartment 70 the clean cool oil picks up its dynamic head and passes into scroll 64.

Oil in scroll 64 is supplied to line 72 under its dynamic head, and line 72 communicates with the

50 main oil supply gallery 23. A conventional relief valve 74 is provided to spill excess oil back to the pump inlet line 80. The relief valve 74 obtains its reference pressure from one of the bearing chamber via a line 76.

55 Thus it can be seen that by suitable positioning of the vents in the bearing chambers, it can be arranged that at least one of the vents is returning oil under pressure to the scavenge line 60 no matter what the attitude of the aircraft is, or what

60 "g" forces are acting on the oil system.

Thus in this embodiment the first re-circulatory oil system is constituted by the breather/pump 30 having a first inlet in the oil tank 18 which supplies oil to the breather/pump compartment 70 under

65 normal or non-aerobatic flight of the aircraft, scroll

64 having an outlet to the main oil supply gallery 23, scavenge line 60 which returns pressurised oil from the bearing chambers to the gearbox 22 and the breather/pump compartment 31 which returns

70 the separated oil to the tank 18. The second re-circulatory system is constituted by the breather/pump compartment 31 which has its inlet in the gearbox to which the scavenge line 60 returns oil from the bearing chambers, and which

75 has a common outlet in scroll 64 with the first system for pumping the oil to the main oil gallery 23.

Clearly the scroll 64 must be preferentially sited in order to ensure that under any flight conditions

80 of the aircraft the main pump outlet is always supplied with oil.

In an embodiment in which the breather in the gearbox provides one or both of the primary and secondary pumping functions the oil tank may

85 form part of the gearbox. In this case it is merely necessary to provide two separate inlets to the two pumps at different locations in the gearbox to which oil gravitates under different aerobatic conditions so that at least one of the pumps is

90 always supplied with oil for operation no matter what the aircraft attitude is.

Figure 5 shows a modification of the Figure 2 arrangement in which the valves 37 and 38 are eliminated by modifications to the oil tank 18. The

95 remaining features of the Figure 2 arrangement are given the same reference numerals in Figure 5.

The tank 18 in this modification is provided with a baffle 90 which extends from the mid-height of the tank towards the bottom (in normal flight), where a dished oil catcher 91 is provided to which is connected the inlet 19 of the main pressure pump 20 of the system. The oil returning from the breather/pump 30, instead of joining the scavenge 26, is taken separately back to the tank

105 18 through line 35, and is directed as a jet between the baffle 90 and the side-wall of the tank.

The first re-circulatory system thus remains unchanged and comprises the main pump 20 and

110 scavenge system 24, 25 and 26. The second re-circulatory system now however, includes both pumps 20 and 30 and operates as follows: When the aircraft inverts, the oil in the bottom of the tank falls away, and the breather/pump 30 returns

115 oil from the bearing chamber vents 27 back directly to the tank 18 via line 35. The returned oil is directed at the catcher 91 and enters the inlet 19 of the main pump 20 which thus continues to operate normally. Thus the second pump 30 still

120 has its inlet 31a disposed at a location 29 in the gearbox 22 to which the oil migrates during inverted flight, but now the oil is supplied indirectly from the pump 30 to the bearings via the tank 18 and the main pump 20, before being

125 returned to the location 29 from the bearing chamber vents 27.

CLAIMS

1. An oil system for an aircraft gas turbine engine comprising a first re-circulatory oil supply

- system for supplying oil to the engine bearings under some flight conditions of the aircraft, and including a pump having an inlet for receiving oil from a first location in the engine and means for returning the oil to said first location of the engine from the bearings under said flight conditions of the aircraft, and a second re-circulatory oil supply system for supplying oil to the engine bearings at least under certain other flight conditions of the aircraft, said second system including a pump having an inlet disposed in another location of the engine to which engine oil migrates during said other flight conditions of the aircraft and means for returning the oil to said other location from the bearings during said other flight conditions of the aircraft.
2. An oil system as claimed in claim 1 and in which a first vent or vents is provided in the bearing chamber through which oil is drained during some flight conditions of the aircraft and a second vent or vents is provided in the bearing chamber through which oil is drained from the chamber under said other flight conditions of the aircraft.
3. An oil system as claimed in claim 2 and in which the engine bearings are situated in bearing chambers which are pressurised by air from the engine compressors and the bearing chambers are scavenged at least partially by the outflow of said air through the first and second vents.
4. An oil system as claimed in claim 3 and in which the first of the re-circulatory oil supply systems includes a first pump having an inlet in an oil tank on the engine and the first vent or vents communicate with the oil tank through a first scavenge system, and the second re-circulatory oil supply system includes a second pump having an inlet in the engine gearbox, and the second vent or vents communicate with the gearbox.
5. An oil system as claimed in claim 4 and in which a rotary air/oil separator is situated in the engine gearbox, said separator comprising at least one rotatable compartment containing a porous material into which an air/oil mixture entering the separator inlet is directed, and from which

- separated air is vented to atmosphere and separated oil is returned to the oil tank, and wherein the air/oil separator constitutes the second pump and is arranged to supply at least a part of the separated oil to the engine bearings instead of the oil tank via a bleed line and flow control valve arrangement under said other flight conditions of the aircraft.
6. An oil system as claimed in claim 5 and in which the control valve arrangement comprises a first relief valve in parallel with the first pump and which is set to maintain the oil pressure in the main oil supply line at a pre-determined pressure, a non-return check valve in the bleed line through which oil from the second pump passes to the main oil supply line, and a second relief valve which controls the pressure in the bleed line upstream of the check valve and which is set at a pressure lower than that of the first relief valve.
7. An oil system as claimed in claim 3 and in which a rotary air/oil separator is situated in the engine gearbox, said separator comprising at least one rotatable compartment containing a porous material, which, on rotation, generates a pumping action and constitutes a pump for both the first and second re-circulatory oil systems, a first inlet to the pump which communicates with an oil tank on the engine, a second inlet to the pump to which is delivered an air/oil mixture from the bearing chambers of the engine, a first oil outlet from the pump which supplies the main oil supply line to the engine bearings with oil continuously while the pump is rotating, and a second oil outlet from the pump which communicates with the engine oil tank and returns excess oil received by the pump back to the oil tank.
8. An oil system as claimed in claim 1 and in which the second re-circulatory system includes means for supplying oil from the pump to the first location and for directing it into the inlet of the pump of the first re-circulatory system which then supplies the oil to the bearings.
9. An oil system substantially as hereinbefore more particularly described with reference to the accompanying drawings.